112 Bunches in RHIC

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112 Bunches

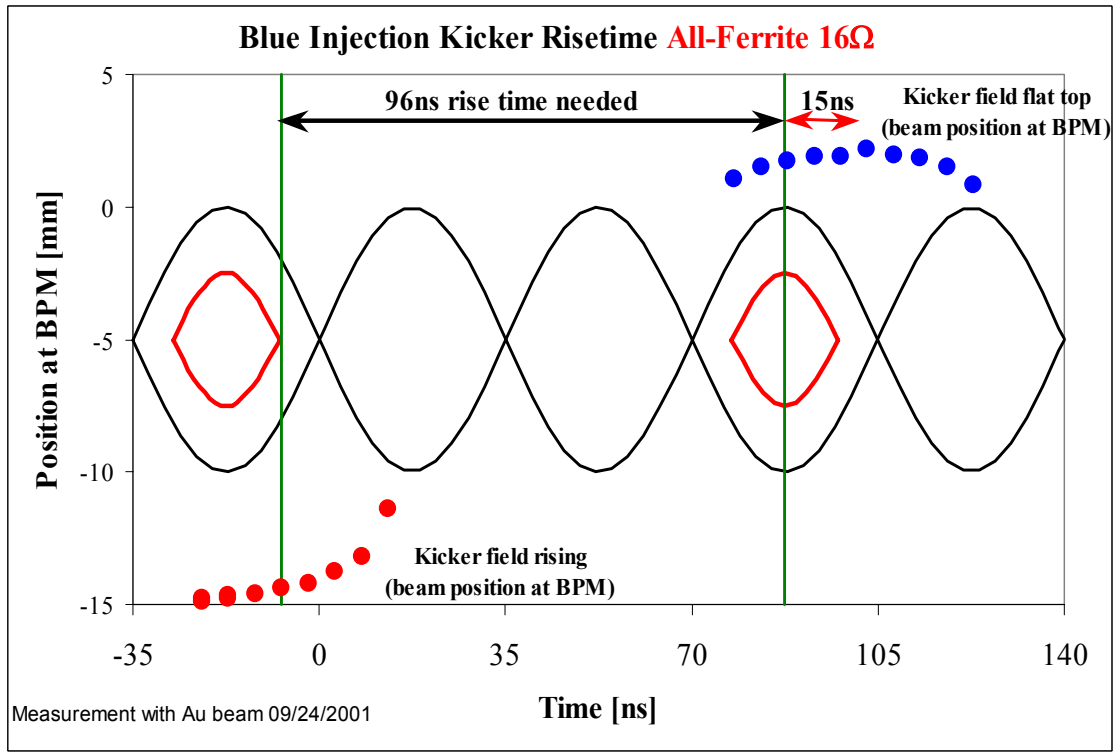
- What is the best number of bunches?

$$Lumi \propto (No\ of\ bunches) \times (No\ particles\ per\ bunch)^2$$

- 112 bunches could potentially double the luminosity, but only if the bunch current can be maintained
- If possible, it is better to increase the bunch current, even if the number of bunches is decreased
- 112 bunch operation is beyond design manual specs
- Areas of concern for 112 bunch operation:
  - Injection kickers
  - RF
  - BPMs ($\rightarrow$ T. Satogata)
  - **Pressure rise** ($\rightarrow$ S.Y. Zhang, H.-C. Hseuh)
  - Transition ($\rightarrow$ C. Montag, M. Blaskiewicz)

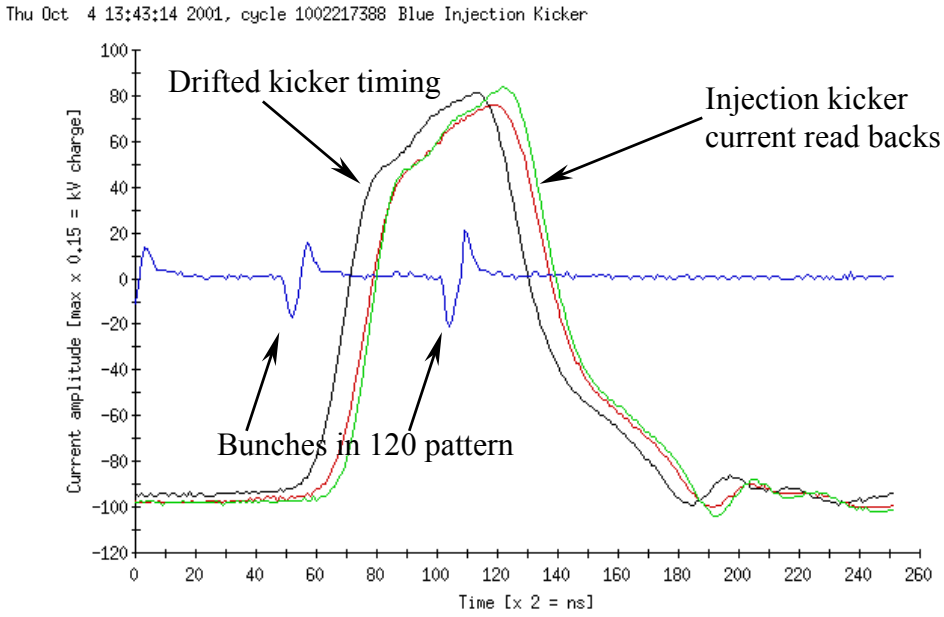
Injection Kicker Rise Time

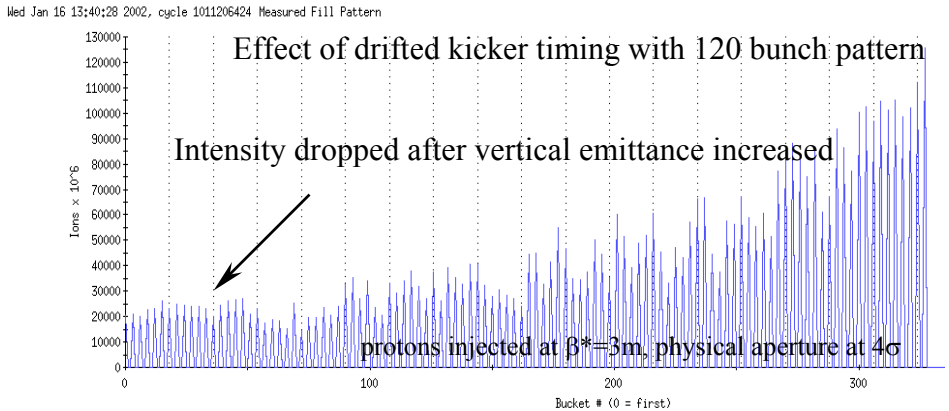
- New all-ferrite injection kickers (H. Hahn) more robust, no failure so far (had to replaced 3 of the old kickers)
- Rise time **marginal**, may be improved:
  - Better matching of termination (cable voltage too high?)
  - Injecting closer to flat top front
  - Support from injection damper
- Shorter bunches are better



Injection Kicker Timing Stability

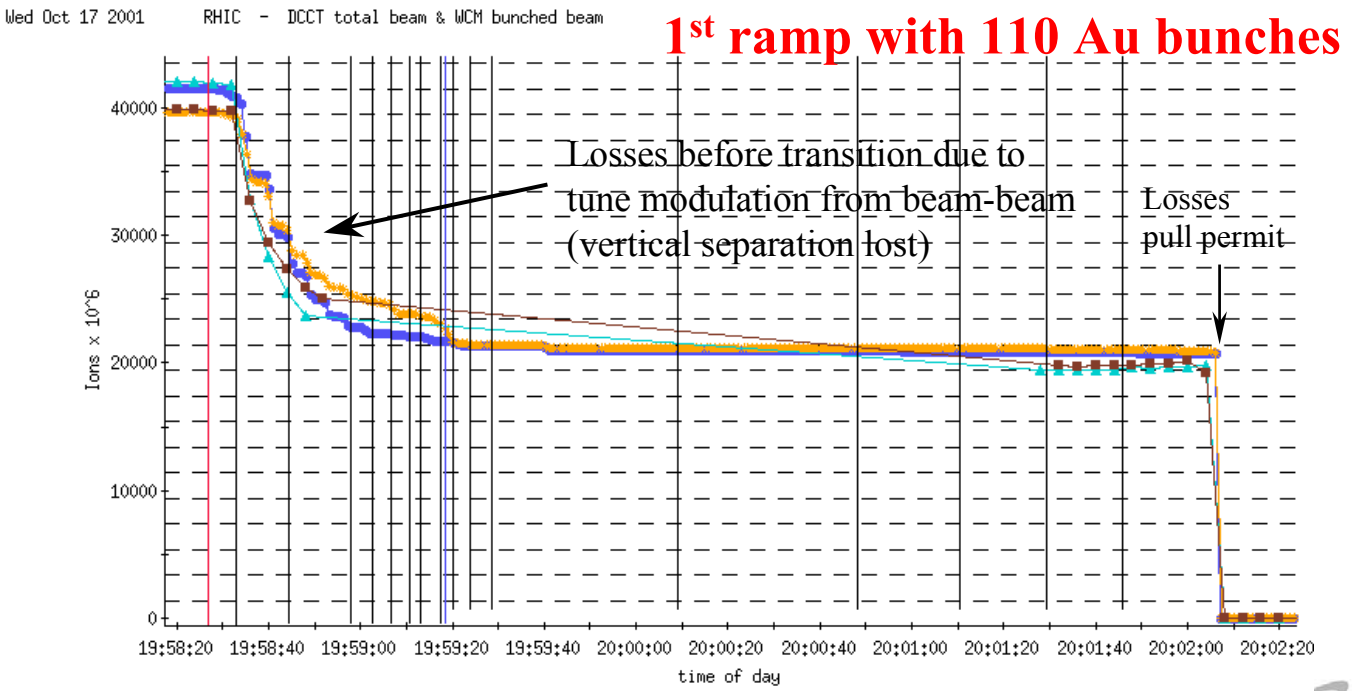
- Timing of kicker modules not absolutely stable, **not acceptable** with marginal rise time
- Drifted timing leads to vertical emittance increase of preceding bunch, possibly beam loss
- Hardware changes needed (W. Zhang), or increased maintenance (~weekly re-timing)





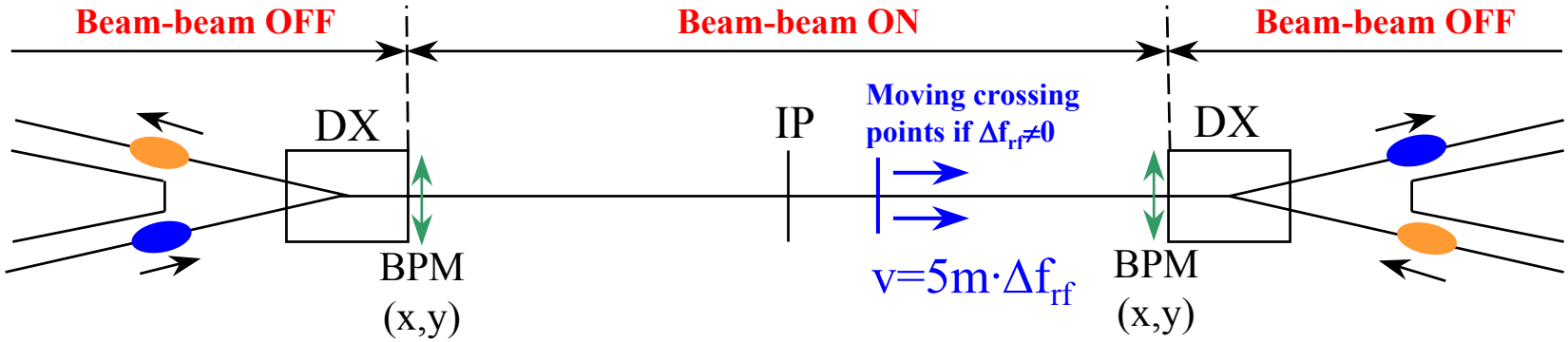
RF – Phase Detector

- Phase detector modifications were implemented for 120 bunch pattern (T. Hayes, L. Hoff) – every other bunch ignored
- Successful test ramp (110 each with low intensity)
- Better solution for next run – even and odd bunches sampled alternatively turn-by-turn



Synchronization of Blue and Yellow RF

- No longitudinal separation possible in 120 bunch pattern



- Synchronization of Blue and Yellow RF would limit beam crossings per IP to 1 (**1 or 2 without synchro**)
- Synchronized beams have un-modulated beam-beam tune spread that scales with intensity (can also be used for Landau damping with 55 bunches)
- Synchronization only tested at injection (M. Brennan)

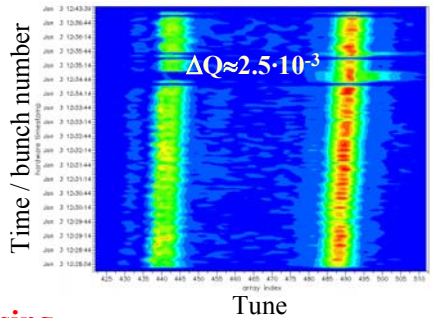
Pressure Rise

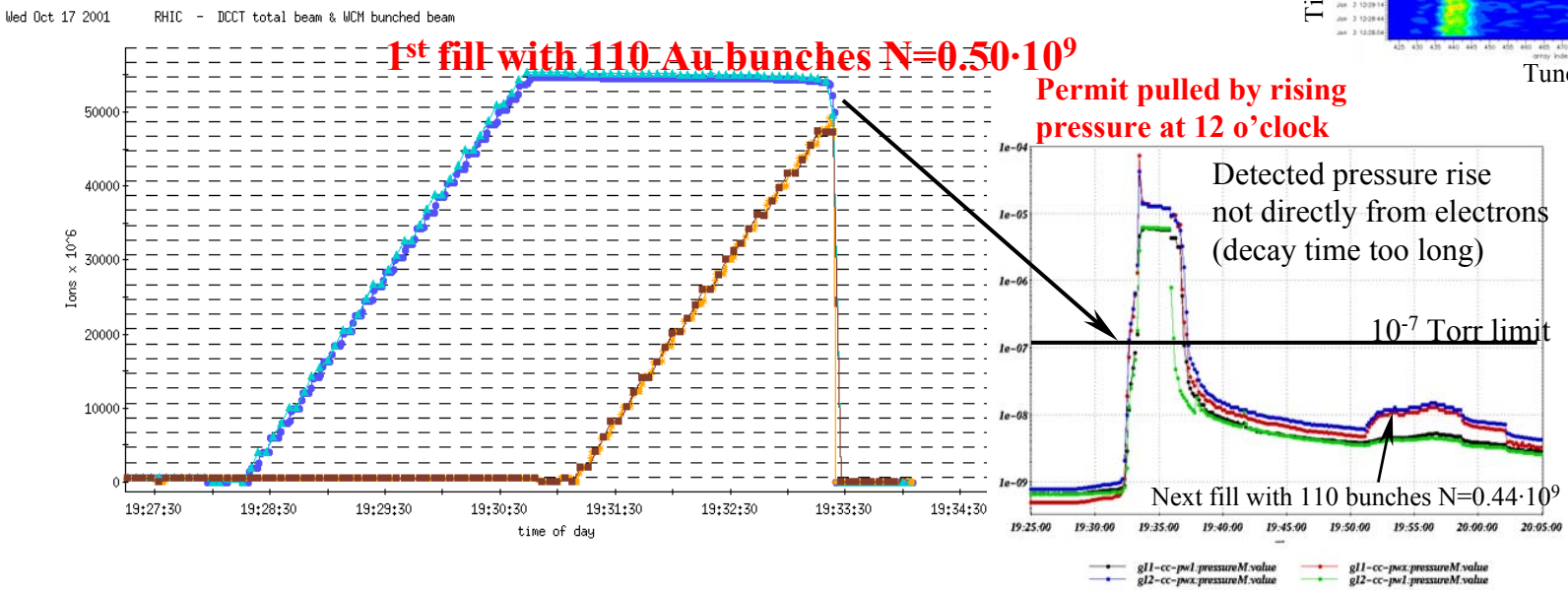
- Relevant beam parameters:
  - Bunch spacing (shorter spacing worse)
  - Ion species (no problems seen with protons, but no real 110 bunch test)
  - Intensity (very sensitive)
  - Not: charge per bunch

$\Rightarrow N_b Z^n$?

Pressure rise possibly related to e-clouds: Coherent tune shift observed along bunch trains in both planes

Yellow coherent tunes while being filled with 110 p bunches, Blue already filled with 110 p bunches (T. Satogata)





Pressure Rise Cont'd

- Always in warm (field free) regions
- Faster with higher intensity (very sensitive) and shorter bunch spacing (216ns $\rightarrow$ 108ns)
- Faster with two beams
  (effective shorter spacing in common regions)
- Typically with loss producing situations
  (injection, transition, orbit problems)
- Experimental solenoid magnet (~0.5T)
  ameliorates pressure rise
- Gaps of 1μs do not help

Summary 112 Bunches

- Injection kickers have marginal rise time and timing stability for 112 bunch operation
  → Hardware improvements or increased maintenance needed
- Synchronization of Blue and Yellow RF limits beam crossings per IP to 1, and avoids tune modulation
  → Can also provide un-modulated tune spread in 55 bunch operation
- No problems expected from BPM system or other instrumentation
- Pressure rise is the limiting effect for 112 bunch operation
  → May prevent 112 bunches for gold
  → Possibly ok for protons